[Proc. Roy. Soc. Victoria, 53 (N.S.), Pt. I., 1941.]

Art. VI.—The Granites of the Terricks Range and Lake Boga, in Northern Victoria.

By EDWIN SHERBON HILLS, Ph.D., D.Sc.

[Read 11th July, 1940; issued separately 1st February, 1941.]

Introduction.

In the district between Mitiamo, Terrick-Terrick, Pyramid Hill, and Mt. Hope in County Gunbower, groups of low granitic hills rise above the almost featureless alluvial plains of the Northern District. The Terricks Range, which extends northwards from Mitiamo and terminates north-east of the outstanding landmark formed by the conical peak of Pyramid Hill, constitutes the main granitic terrane, but outlying hills such as Mt. Hope extend the area in which granites occur to over 60 sq. miles. The most southerly outcrop, at Mitiamo, is nearly 40 miles distant from the northern boundary of the Central Highlands (see Physiographic Map of Victoria in Hills, 1940), and as no exposure of the country rock that was invaded by the granites has been observed, direct evidence of their age is not available.

The boundaries of the granites were mapped by the Geological Survey during the preparation of the 1908 edition of the geological map of the State, and the map accompanying this paper (fig. 1) reproduces the data from the original survey in more detail. Major Mitchell, who ascended Mt. Hope and Pyramid Hill in 1836, gives sketches of both these hills, and states that the rock is granite (Mitchell, 1835, Vol. II., pp. 155-9). Brief remarks on the physiography of the district, illustrated by aerial photos, have already been published by the present author (Hills, 1940, see Index), but no account of the petrology of the granites has previously appeared.

The granitic outcrop at Lake Boga in County Tatchera occupies a small area (of the order of 1 sq. mile) about 7 miles south of Swan Hill. It is 50 miles distant from the northern boundary of the Central Highlands, 45 miles from the isolated granite knoll at Wycheproof, and about the same distance from Pyramid Hill. The location of the occurrence is incorrectly shown on the 1908 geological map (8 miles to 1 inch), but has been correctly represented on maps of north-western Victoria previously published by the author (Hills, 1939, fig. 1; 1940, fig. 321, p. 243). I am indebted to Mr. W. Baragwanath for the use of MS. maps of the Terricks Range and Lake Boga, on which my published maps and field work have been based, and also to Mr. G. Baker for heavy mineral analyses of the rocks whose Index Numbers are given below.

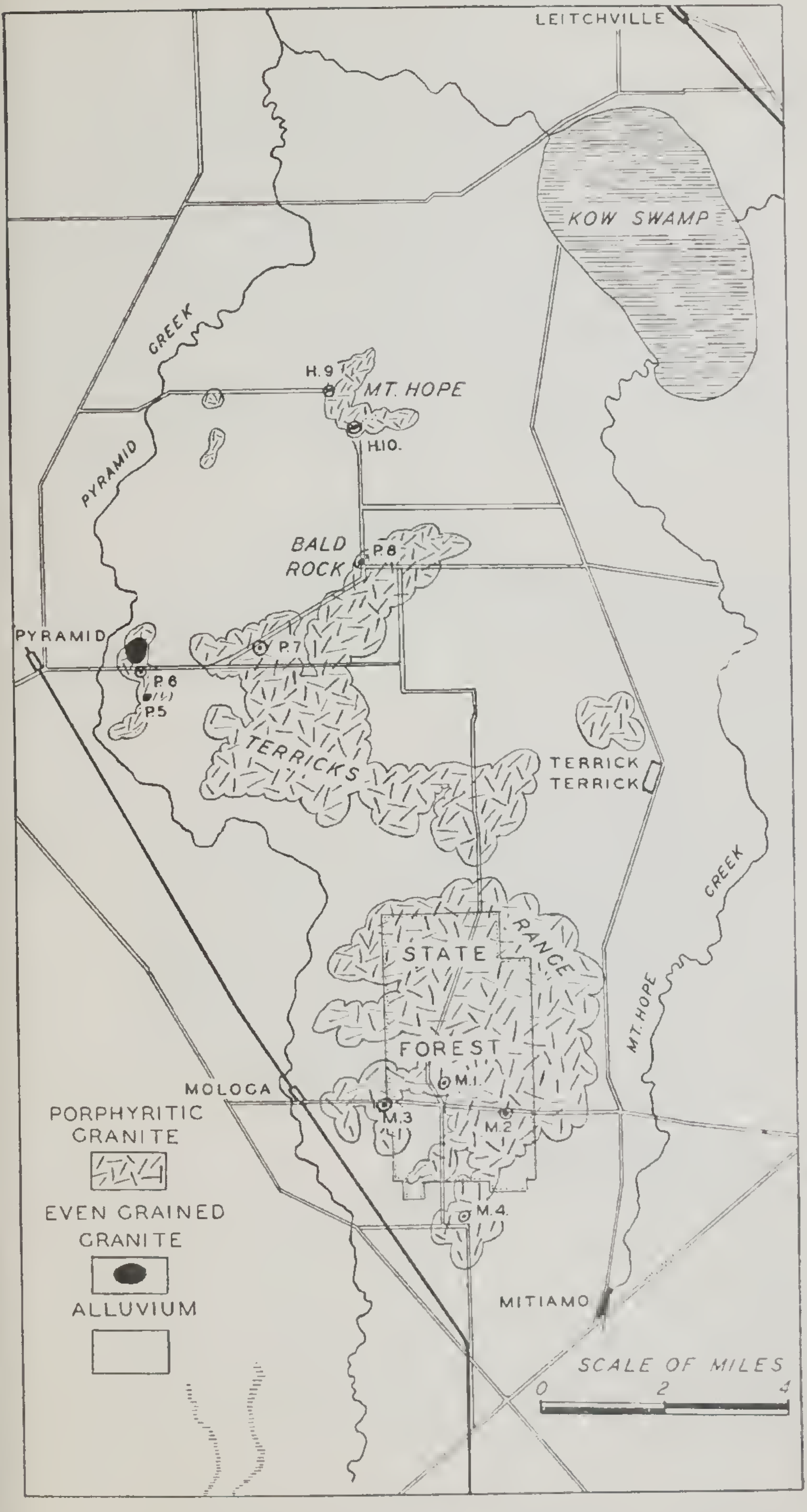

FIG. 1.—Geological map of the Terricks Range.

[Page 267.]

The Granites of the Terricks Range.

Field Occurrence.

The granites of the Terricks Range and neighbouring districts outcrop as tors and bare rock faces at and near the summits of knolls that rise abruptly from marginal alluvial fans, these emerging gradually into the surrounding alluvial plains (fig. 2). Fresh specimens of the granite are only rarely obtainable from natural exposures, for the rock is generally weathered to a considerable depth, in such a way that, though it may remain intact, boulders will shatter under the hammer. This results from loss of cohesion between the mineral grains owing to insolation, followed by the deep penetration of weathering agents along minute cracks.

Fig. 2.—Pyramid Hill, from the north. Note the abrupt change from the rocky hill-sides to the smooth contours of the surrounding alluvial fans.

All the granites in this district, with the exception of that of which Pyramid Hill is composed, are of porphyritic habit, containing large white phenocrysts of micro-perthite averaging about $1\frac{1}{2}$ inches in length, also smaller phenocrysts of quartz, felspar, biotite, and subordinate muscovite, with a minor amount of granular, leucocratic, interstitial base. The Pyramid Hill granite is, however, even-grained, consisting of cream or white micro-perthite, quartz, biotite, and abundant muscovite.

At many localities the perthite phenocrysts show a definite parallelism, with their long axes orientated east-west (fig. 3), but this regular arrangement is not found in all parts. The proportion of phenocrysts to groundmass also shows considerable variation, some patches of a few square yards being non-porphyritic, other small patches crowded with phenocrysts, as in the new quarry at the foot of Pyramid Hill. At Mitiamo (Loc. M.2)—see map for localities mentioned—also at the new Pyramid Hill quarry (Loc. P.6) and nearby at Loc. P.7, biotite-rich schlieren of undulating habit occur, associated with patches of granite crowded with perthite phenocrysts, some of which project into the schlieren, in a manner resembling that described by Baker (1936) at the You Yangs. Xenoliths are rare in most parts of the district, but a few were obtained from Mitiamo (Loc. M.3), also from Pyramid Hill at Locs. P.6 and P.7. The xenoliths are fine-grained biotite-rich types, some of which contain porphyroblasts of felspar.

Aplites, quartz porphyries, pegmatites, and graphic granites occur as narrow dykes or veins in many parts, but all these differentiates are very subordinate in volume to the granites. The dykes and veins typically follow joint planes, especially the nearly vertical east-west joints, with which the flow lines revealed by the micro-perthite phenocrysts are parallel. Approximately vertical north-south joints and flat-lying joints are also well developed, the latter often determining the occurrence of extensive bare rock faces, or pediments on which tors rest.

Owing to the absence of other hard rocks in the disrict, the granites are of considerable economic importance as a source of broken stone for road construction, concrete, and other purposes. Quarries have been opened at Pyramid Hill, but the readily-worked superficial quartzo-felspathic rubble and rotten rock developed by weathering are also extensively used on the roads.

Petrology.

1. Porphyritic (Giant) Granite.

Micro-perthite phenocrysts as large as $2\frac{3}{4}$ in. by 2 in. by 1 in. were observed, but the average length is about $1\frac{1}{2}$ inches. The crystals are tabular parallel to the clinopinacoid, other commonly developed faces being the unit prism, basal pinacoid and hemiorthodome ($\bar{2}01$). Interpenetration Carlsbad twinning is almost universal. Orientation: *c* axis usually east-west; (010) approximately parallel to the flat-lying joints (fig. 3).

Fig. 3. Sketch of a vertical face of granite at Mitiamo, showing the alignment of felspar phenocrysts parallel with the flat lying joint that terminates the face below.

Inclusions are common in the larger perthite phenocrysts. These include sub-rectangular oligoclase crystals showing composition zoning, usually with a sharply-defined outer acid coating or "jacket" (Ab. 85), and a more basic core (Ab. 70). Biotite and quartz are also included in the perthites, especially in the outer parts of large phenocrysts. Typically, the included minerals are arranged in zones, evidently having been incorporated at certain stages during the growth of the perthite phenocrysts. Many of the latter exhibit composition zoning, and the composition zones are parallel to the lines of inclusions. This zoning is shown by variations in the distribution of fine ex-solution lamellae, as in the potash-felspars described by Trefethen (1937) and Spencer (1938), and is of an oscillatory nature.

The majority of perthites exhibit both the "vein" type of perthite lamellae, and the very fine ex-solution lamellae or threads. The arrangement of the "vein" and ex-solution lamellae is different, as is well shown in slide [5690]. (Note: Numbers in brackets refer to slides registered in the Geology Department, University of Melbourne.) This is cut parallel to (010), and shows the two individuals of an interpenetration Carlsbad twin. The "vein" perthite lamellae are parallel to the vertical axis *c*, but the ex-solution lamellae make acute angles with *c*, the largest deviation (11 deg.) agreeing with the angle of the negative hemiorthodome ($\bar{6}01$). There appears to be no sharp demarcation between the "vein" and ex-solution lamellae (fig. 4E), which grade into each other, especially at the terminations of the "veins".

Slide [5694] illustrates a commonly occurring phenomenon. Along the borders of each "vein" perthite lamella, the host felspar is raised in double refraction to .007, it extinguishes at 9° on the (010) plane, and shows indistinct cross-hatching. In many other examples, as is illustrated by [5711], this apparently triclinic modification is also exhibited, and the cross-hatching is well-developed. The felspar cannot be anorthoclase because of its high double refraction and extinction angle, and it is clearly close to true microcline. This reconstitution of the host K-falspar may be due either to the diffusion into it of Na and Ca from the "vein" perthite lamellae, or to a rearrangement of the monoclinic orthoclase lattice, induced by the adjacent oligoclase-albite of the perthitic "veins." Spencer (1938, p. 107) has recorded a similar effect in mircocline, in which the coarseness of the cross-hatch twinning is regulated by the adjacent "vein" perthite.

Slide [5694] is also interesting because there is a change in the nature of the perthite lamellae in the core of the crystal. The "veins" in the outer layers are polysynthetically twinned oligoclase (Ab. 85), but in the core these grade into untwinned bands of lower double refraction (but still higher than the host), which are monoclinic (fig. 4A, B). In the centre of the core the felspar is "shadow" perthite, of mottled appearance under high magnification. Inclusions of quartz follow the boundary of the core, along which there is also a narrow zone of microcline-like felspar resembling that marginal to the "vein" perthite lamellae.

Slide [5693] is a small perthite phenocryst from Loc. M.1. In preparing the slide, the (010) face was polished without removing much of the felspar, and thus the section shows the nature of the outer coating of the crystal. The major portion is soda-orthoclase, with X $\wedge$ (001), 9°, but the margin consists of two distinct zones, an inner composed of coalesced prismatic crystals in which the extinction angle on the trace of the (001) cleavage is 0°, and an outer of soda-orthoclase in optical continuity with the core. The inner of the two zones grades rapidly by means of composition-zoning into the soda-orthoclase on either side without any definite line of demarcation, and has a distinctly higher double refraction and refractive index. The optical properties therefore suggest that the inner of the two border zones is oligoclase. In its anhedral form, the phenocryst differs from true Rapakiwi, but similar oligoclase margins to potash felspar have been recorded from many localities. The present example is unusual, however, in that the oligoclase is followed by a final orthoclase zone. Apart from the microcline fringing "vein" perthite stringers in orthoclase, this mineral is rare in the district. A few crystals showing uniform cross-hatching occur in slides [5708] and [5719].

Plagioclase in the porphyritic granites is typically oligoclase, ranging in composition from Ab. 70 to Ab. 85. The mineral invariably shows composition zoning, frequently with a marked discontinuity between the core and the outer zones ("jacketed" felspar), the latter also frequently containing myrmekite pustules. The plagioclase in the "vein" perthite lamellae averages about Ab. 85 in composition.

Quartz is hypidiomorphic to anhedral, and is present in large amount in all the rocks examined. It is included in the perthite phenocrysts, often along definite growth zones. These inclusions in slide [5693] are unusually large.

Biotite is pleochroic from X pale yellow or yellow-brown to Y, Z dark brown. The crystals frequently show dactylitic terminations against felspars (both orthoclase and oligoclase), and contain many minute inclusions of zircon and apatite, around which pleochroic haloes are developed. It is rarely altered to chlorite, and shows various stages of bleaching, tending towards colourless hydromica.

Muscovite occurs as well-developed plates, and also as stringers replacing orthoclase or microcline. In places it is intergrown in a lamellar arrangement with biotite. The freedom of this muscovite from inclusions of rutile or sphene distinguishes it from bleached biotite. In the Pyramid Hill Quarry, muscovite-quartz replacements of perthite are especially notable [5719].

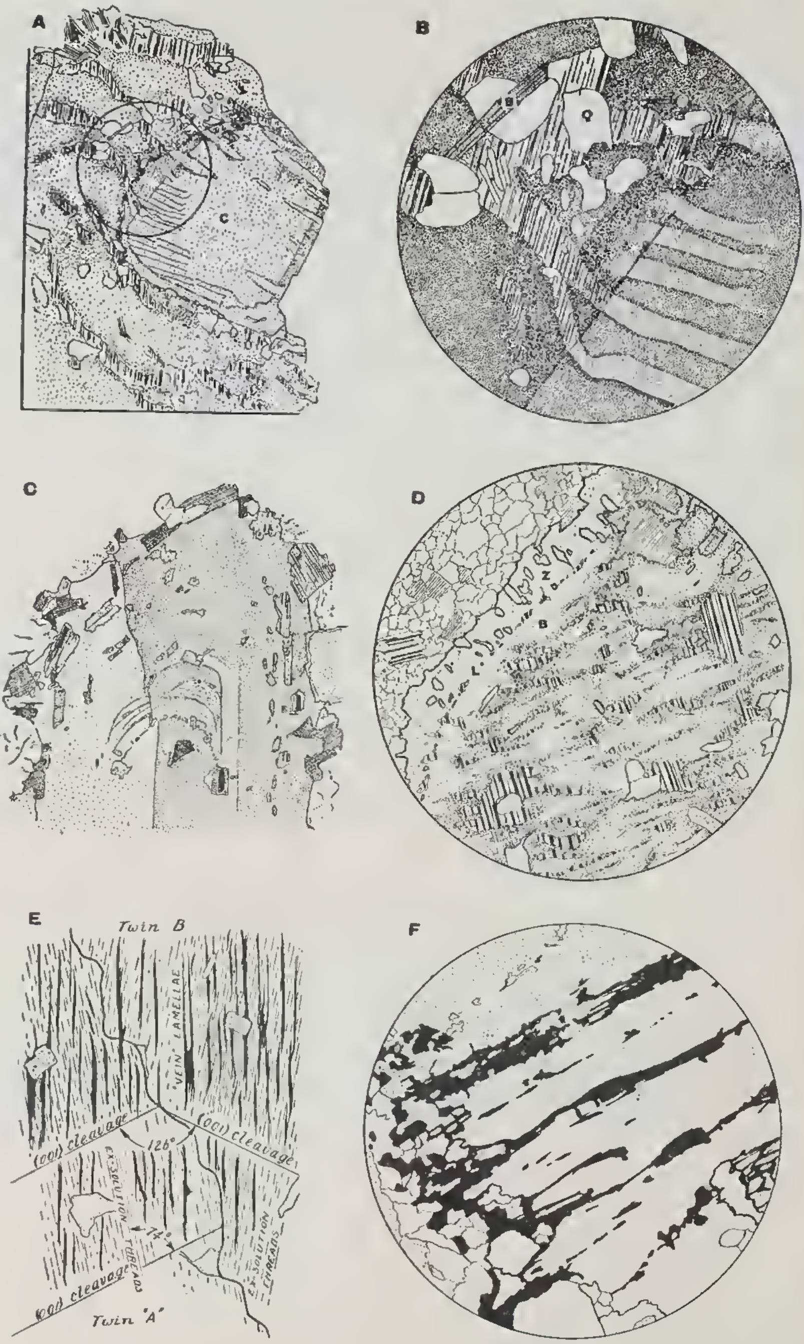
A
B
C
D
E
F
Twin B
VEIN LAMELLAE
(001) cleavage
126°
(001) cleavage
EXSOLUTION THREADS
74°
EXSOLUTION THREADS
(001) cleavage
Twin "A"

FIG. 4.

FIG. 4.—Types of Micro-Perthitic Structures:—

A.—Portion of a perthite phenocryst from the porphyritic granite, Old Quarry Pyramid Hill [5694] X12. Showing the core C, without perthitic lamellae in the centre, but with untwinned lamellae around the margins, these grading into twinned plagioclase (Ab. 85) in the surrounding potash-felspar.

B.—Enlargement of the portion within the circle in A. X36. In both A and B. note the change in the nature of the host-felspar along the twinned perthitic lamellae, as shown by the close stippling. *q*, quartz; *b*, biotite.

C.—Perthite phenocryst in porphyritic granite, Mitiamo. Loc. M4. [5708] X4. Showing composition zoning, and the arrangement of included crystals of quartz, plagioclase, and biotite along growth surfaces, parallel to the composition zones. Note also the tendency for the groundmass crystals, marginal to the phenocryst, to align themselves with long axes parallel to the surface of the perthite phenocryst. Only half the phenocryst is represented in the sketch.

D.—Portion of a perthite in the porphyritic granite, Lake Boga Quarry [5727] X6. Shows a marginal zone *z* containing quartz crystals elongated normal to the potash-felspar crystal face. Beneath this a line of inclusions *l*, of quartz and oligoclase, and beneath this again the body of the phenocryst which is itself bordered with a zone *b* free from perthite lamellae. Note the change in the nature of the host felspar along the plagioclase inclusions as shown by the close stippling.

E.—Perthite phenocryst, Mt. Hope [5690]. Diagrammatic sketch showing the geometrical arrangement of "vein" and ex-solution perthitic inclusions in two halves of a twinned crystal. Section parallel to (010); *c* axis vertical.

F.—Edge of an orthoclase crystal in pegmatitic patch, Old Quarry, Pyramid Hill [5721] X20. Shows replacement of potash-felspar (stippled) by albite (black). Quartz, unshaded.

Accessory minerals present in the granites include apatite, zircon, garnet, ilmenite, and pyrite. The Index Number of porphyritic granite from Pyramid Hill Quarry is 5.61, and from Mt. Hope, 6.25.

2. Even-grained Granite.

Pyramid Hill itself is composed of an even-grained granite which contains abundant muscovite in addition to biotite. A similar type occurs in the old quarry south of the Hill. The granite consists of orthoclase micro-perthite, rare microcline micro-perthite, abundant oligoclase ranging from Ab. 70 to Ab. 85, with biotite and muscovite in sub-equal amounts. Muscovite-quartz associations replace potash-felspar in part. Quartz is abundant, the grains showing sutured interlocking boundaries. Small andalusite prisms are enclosed in the larger muscovite plates [5717, 5718]. Accessory minerals other than andalusite are apatite and zircon. The Index Number is 4.47.

3. Acid Differentiates.

Graphic granite (Loc. H10, slide [5725]) consists of orthoclase-perthite, the intergrown plagioclase consisting of Ab. 70 (oligoclase-andesine). A little muscovite is also present.

Pegmatite occurs as veins and central " combs " in aplite dykes. At Pyramid Hill Quarry, pegmatite veins contain small groups of radiating tourmaline prisms, and consist of orthoclase perthite, oligoclase, muscovite, and quartz [5721].

Aplite dykes are common in both the porphyritic and even-grained granites. Slide [5714] from Mitiamo (Loc. M.3) illustrates the true aplitic types, consisting of quartz, abundant orthoclase-perthite and microcline-perthite, oligoclase (Ab. 80–Ab. 90), very abundant large myrmekite pustules, muscovite, both replacing potash-felspar and as large primary plates, and rare brown or bleached biotite.

Slide [5709] from Mitiamo (Loc. M1) is a rock which in hand specimen appears to be a true aplite, consisting of a fine-grained saccharoidal mass of quartz, felspar, and muscovite. Under the microscope it is seen to contain oligoclase (Ab. 75–Ab. 80), sub-equal to subordinate amounts of orthoclase micro-perthite, rare microcline micro-perthite and abundant quartz and muscovite. The amount of oligoclase present is unusually large, but all the aplitic types sectioned contain larger amounts of this mineral than is usual in granite aplites.

Slide [5715] is an aplitic type that intrudes the even-grained granite of Pyramid Hill. It contains orthoclase-perthite, subordinate oligoclase, a little biotite in large and small flakes, some bleached biotite, muscovite, and andalusite. Coarse patches a few square centimetres across consist of quartz, large muscovite plates, and andalusite.

Porphyry Dykes: A fine-grained dyke at Loc. P8 (slide [5726]) contains small phenocrysts of quartz, felspar, and biotite, averaging about $\frac{1}{4}$ cm. across. Zoned ("jacketed") oligoclase (Ab. 70–Ab. 85) is the dominant felspar, and orthoclase-perthite is subordinate. The other constituents are quartz, biotite (some bleached), and subordinate muscovite. The rock is a quartz porphyrite.

A similar porphyry dyke at Mitiamo (Loc. M1, slide [5713]) contains more orthoclase-perthite, together with some microcline-perthite, though oligoclase is present in sub-equal amounts to potash-felspar. Biotite and muscovite are both present, the latter both replacing potash-felspar and in large primary crystals. This dyke is also a quartz porphyrite.

The largest dyke observed is at Mitiamo, Loc. (M3, slide [5695]). It is about 10 feet wide, strikes at 35°, and is crowded with quartz and felspar phenocrysts averaging about 5 mm. in diameter. In places the felspars are subordinate, and the rock consists of quartz phenocrysts with very little groundmass. The felspars are all completely altered to fine-grained aggregates of limonite-stained sericite, and their original nature is not determinable. The groundmass consists of quartz, sericitised felspars, and partially or completely bleached biotite. The rock is a sericitised quartz porphyry. It carries narrow quartz veins that have been prospected for gold.

4. Melanocratic Schlieren.

The biotite-rich schlieren at Loc. P8, slide [5706], and at Pyramid Hill Quarry, slide [5720], contain large plates of biotite, many being joined together at their ends, where they interdigitate without leaving interstices. Large stout apatite prisms up to 0.5 mm. long are associated with the biotite. The other constituents are orthoclase micro-perthite, oligoclase (Ab. 70), quartz, and subordinate muscovite. Myrmekite is developed in the oligoclase jackets; accessory minerals include apatite in stout prisms up to 0.5 mm. long, also a little apatite in the form of small needles, and zircon.

Slide [5704], from Loc. P7, is fine-grained, but contains a few porphyroblasts of biotite, quartz, and felspar. It shows no banding. Biotite occurs in the manner characteristic of reconstituted xenoliths, as scattered crystals distributed evenly throughout the rock. Many of the biotite flakes are smaller than in slide [5703], and some adjacent small flakes are in parallel orientation, enclosed within a quartz unit. The quartz occurs as plates, full of inclusions of other minerals, the different parts of which are in optical continuity, as described by Brammall (1932) in xenoliths from the Dartmoor granite. In some of these quartz units the included plagioclase and biotite show a radial arrangement, tending towards spherulitic texture. The boundaries of the quartz plates in places assume a regular geometrical arrangement simulating micrographic intergrowths. One biotite porphyroblast exhibits a large central homogeneous crystal surrounded by a solid mass of irregularly arranged decussate biotite flakes (Baker, 1936, p. 139). The felspar porphyroblasts are oligoclase (Ab. 75–Ab. 85), and the cores of some of the smaller plagioclase crystals are andesine, with jackets of oligoclase grading to (Ab. 85). No potash felspar is present. Apatite occurs as rare stout prisms associated with large biotite clots, and also as numerous needle-shaped inclusions in quartz and plagioclase.

Slide [5705] from Loc. P8 is mineralogically similar to [5704], but the texture of the rock is different. The quartz hosts in which inclusions occur are more compact, containing a smaller proportion of included grains. The felspars are larger, and are also poikilitic. They consist of andesine (Ab. 65) jacketed with oligoclase ranging up to Ab. 85. Potash felspar is absent. (Note: The perthite on the edge of this slide is part of the adjacent granite.) The other constituents are a little muscovite, apatite in the form of long needles (rarely stout prisms), and zircon.

Slide [5707], from Pyramid Hill Quarry, is also similar in a general way to [5704], but the quartz poikiliths assume a pseudomicrographic arrangement, with regular geometrical boundaries to the sieve-like crystals. Quartz intergrowths with oligoclase also assume a form resembling coarse myrmekite, as described by Brammall (1932). Biotite develops as plates or fringing aggregates surrounding ilmenite grains, and is specially poikilitic, containing numerous inclusions of quartz in optical continuity among themselves. The felspar is oligoclase-andesine, no potash-felspar being present. Large apatite prisms, up to 0.5 mm. long, as well as numerous thin apatite needles, occur.

The Lake Boga Granite.

In the Lake Boga Quarry, which is the only locality where the local granite may be studied in the field, jointing is well developed. One set strikes at 100° and dips at 85° to the north. The complementary approximately vertical joints strike at 190°, and flat-lying joints are also present. All the joints are mineralised, narrow pegmatite selvedges containing black tourmaline crystals up to 8 inches long being developed along them. The granite itself is very heterogeneous. The average is a giant granite porphyry containing phenocrysts of microperthite of a flesh-pink to greenish tinge and about 1½ inch long, together with phenocrysts of muscovite, biotite, and quartz, the largest of these being about ½ inch across. These crystals are set in a finer-grained granular base composed of the same minerals. Leucocratic patches up to 3 or 4 feet long are free from the large perthite, quartz and mica phenocrysts, but contain patches, veins, and vughs of tourmaline pegmatite, consisting of quartz, perthite, muscovite, and black tourmaline. The distribution of phenocrysts also varies within the giant granite, lenticular patches being crowded with phenocrysts, while others are even-grained. The latter are darker than the pegmatite-bearing leucocratic varieties. On one face of a few square yards, the giant granite contains numerous xenolith-like blebs up to 6 inches across with hazy borders, and numerous phenocrysts of quartz and felspar. Granite has also been obtained from the Lake Boga Prospecting Company's Bore, at a depth of 200 feet. This is a coarse-textured grey rock containing a considerable amount of biotite, together with quartz and micro-perthite crystals, the latter ranging up to over half an inch in diameter. The available specimens are not large enough to afford an adequate sample of the granite.

THE PORPHYRITIC GRANITE.

This contains large micro-perthite phenocrysts, individual crystals consisting both of monoclinic orthoclase hosts, and triclinic hosts with incipient cross-hatching, developed, as above described, along "vein" perthite lamellae. The latter consist of acid oligoclase (Ab. 80–Ab. 85). Along one edge of the large phenocryst in slide [5727] there is a zone of orthoclase free from "vein" perthite lamellae. This zone is followed by a narrow band along which minute quartz and acid oligoclase crystals are included, and this in turn by an outer zone of orthoclase free from "veins," but including small quartz crystals, most of which are elongated along the *c* axis and lie at right angles to the orthoclase boundary. In the interior parts of the perthite, the "vein" lamellae are arranged in a zonal way, the outlines of the zones being parallel to the crystal boundaries, and evidently related to growth stages. Oligoclase (Ab. 70–Ab. 80), quartz, muscovite, and yellow to red-brown biotite occur as phenocrysts, and the groundmass, which is fine grained, contains perthite, oligoclase, quartz, biotite (some bleached to colourless hydromica, in various stages) and muscovite. Muscovite and biotite are in places intergrown, and minor amounts of muscovite also replace potash felspar. Heavy accessory minerals are rare, apart from tourmaline. There is a little apatite and zircon.

Slide 2043 (Geological Survey Collection) is essentially similar, but is interesting in that the outer acid jacket of oligoclase crystals (Ab. 85) included in perthite is optically and morphologically continuous with the plagioclase of the "vein" lamellae.

Grey Leucocratic lenticles with Pegmatite: The leucocratic base in which the pegmatite vughs and veins are dispersed is a medium-grained, granitic-textured rock consisting of quartz, orthoclase, microcline (with indistinct cross-hatching), abundant plagioclase (andesine Ab. 65 to oligoclase Ab. 80), and muscovite. Biotite is absent, and the potash felspar is free from perthitic lemellae.

both of the "vein" and ex-solution types [5697, 5698]. The felspars are cloudy with alteration products, the potash felspar being more altered than the plagioclase. The chief alteration is kaolinisation, but there is also some development of opacity due to finely-divided limonite. The latter may represent a weathering product of hematite introduced during deuteric alteration, and the kaolinisation is also most probably deuteric. The Index Number is 6.25, being identical with that of the Mt. Hope granite.

The pegmatites are not particularly coarse-grained, the crystals averaging about half an inch to one inch in size. They consist of smoky quartz, muscovite, cream perthitic orthoclase grading to microcline, rare apatite crystals as large as the other constituents, and, in patches, black or translucent tourmaline up to 8 inches long.

Pink Lenticular Patches: These are distinguished from the giant granite by absence of perthite phenocrysts, and from the leucocratic grey lenticles by the absence of pegmatite vughs and veins, and by their colour. They are similar to the leucocratic patches in mineral content, except that they contain a large amount of colourless to pale brown and dark brown tourmaline, in the form of skeletal crystals. They also contain a little biotite intergrown with muscovite, and a few anhedral grains of apatite, up to 0.5 mm. across. The larger quartz grains show evidence of regrowth along their margins, and the felspars are again kaolinised and limonite-stained, the potash felspar, as in the leucocratic lenticles, being more strongly altered than the plagioclase [5694, 5700]. The Index Number is 10.14, being abnormally high owing to the presence of tourmaline in large amounts.

The dark xenolith-like patches a few inches across, which occur in the giant granite, are actually tourmaline-bearing clots, similar to the pink lenticular patches except that they contain much more tourmaline, and also carry phenocrysts of quartz, perthite, and plagioclase, like the giant granite.

The granite from the Lake Boga Prospecting Company's bore contains quartz, zoned oligoclase ranging from (Ab. 78 to Ab. 87), perthite, biotite, and muscovite. Slide 2182 (Geological Survey Collection) also contains a biotite-rich clot which is probably of xenolithic origin. It is a biotite-muscovite granite.

Petrogenesis.

Notable features of the above-described rocks are:—(1) the occurrence of two-mica granites, (2) the occurrence of porphyritic granites, and (3) the presence of andalusite in granite and aplite at Pyramid Hill.

The andalusite-bearing rocks are especially interesting in view of the great rarity of xenoliths or other evidences of contamination throughout the province, and have already been discussed by the author in a previous communication (Hills, 1938). The presence of apatite in pegmatites at the Lake Boga Quarry is also noteworthy, although the amount present is insignificant from the point of view of economic potentialities.

1. *Perthite.*—Ex-solution perthite, and the coarser sub-parallel or ramifying lamellae of the "vein" type appear to grade into each other in many of the slides examined, but the "vein" lamellae are markedly coarser than the very fine ex-solution threads. It has been suggested by E. Spencer (1938) that "vein" perthite is formed by the simultaneous crystallization of plagioclase and the potash felspar host. The hypothesis relates specifically to the microline micro-perthites examined by Spencer, but should presumably be applicable also to orthoclase micro-perthites such as those in the suite here considered. It would be expected, on this hypothesis, that the "vein" plagioclase in the interior of a large potash-felspar crystal would be more calcic than that nearer the periphery, and a more or less regular composition-zoning of the veins might also be developed during crystallization. Such a condition is certainly not typical of the micro-perthites in the rocks here described, although in one example (fig. 4 A, B [5694]) the veins in the core are untwinned and may be composed of a potash-soda-lime felspar rich in potash and soda, while in the outer parts they are twinned oligoclase (Ab. 85). This unusual arrangement is, however, also explicable as due to the unmixing of an original potash-soda-lime felspar which itself had a central core differing in composition from the outer layers.

On the assumption that the plagioclase "veins" are actual injections into or replacements of shattered potash felspar, one would have expected to find inclusions such as quartz and oligoclase traversed by the vein plagioclase, in at least a few examples. This does not occur. Vein injection or replacement, too, would not be likely to give rise to the regular distribution of perthite lamellae throughout large crystals, that is actually observed. It is worthy of note, too, that many albitic replacements of potash felspars in pegmatites show no resemblance to typical perthitic lamellae (see fig. 4 F; also Derry, 1931; Niggli, 1929, figs. 4 and 5). It is therefore suggested that both the "vein" and ex-solution perthitic inclusions resulted from the unmixing of an original potash-soda-lime felspathic solid solution.

2. *Late-Magmatic Phases.*—In both the Terricks Range and Lake Boga granites, differentiation has yielded late-magmatic fractions relatively rich in oligoclase, such as the porphyries and aplites of the Terricks Range, and the leucocratic patches in the Lake Boga granite. The mineral constitution of these aplitic differentiates closely resembles that of the ground-mass of the porphyritic granites. The suggestion is, therefore, that the final magmatic fluid remaining after almost complete solidification of

the potash-felspar-rich granites was relatively enriched in plagioclase (oligoclase). If these differentiates were expressed from the crystal mesh, they produced aplites. The inclusion of small oligoclase crystals along growth lines in the perthite phenocrysts, though not decisive, also suggests that at certain stages the crystallization of potash felspar was retarded, while acid plagioclase was concentrated within the sphere of influence of each perthite phenocryst, until the magma became saturated and oligoclase crystallized.

The pegmatites, on the other hand, contain high-temperature potash felspars in large amount. They are of the type termed "simple pegmatites" by Schaller, in which no extensive replacement of original minerals has gone on, and their formation is readily explicable on the basis of the principles established by Niggli (1929, pp. 2-5).

3. *Jointing.*—All three joint sets in the porphyritic granites—the approximately vertical east-west and north-south joints, and the flat-lying joints—are locally filled with aplitic or pegmatitic veins, and are therefore primary.

4. *Age Relationships.*—Field relationships indicate that the non-porphyritic granite at Pyramid Hill is intrusive into the porphyrtic granite. The profile of Pyramid Hill (see fig. 2, and Hills, 1940, figs. 132, 329), suggests that the even-grained granite is a dyke-like mass, dipping easterly at about 45°, and striking east of north to west of south. It is probable, therefore, although the intervening area is marked by alluvium, that the outcrops at Pyramid Hill and the old quarry are connected along the strike of the dyke.

5. *Petrographic Relationships.*—The minor intrusions of granitic rocks that occur around the fringes of the Murray Basin Plains in north-western Victoria exhibit certain petrographic peculiarities that indicate the existence of a minor petrographic province in this region, perhaps distinct from the Devono-Carboniferous intrusions in the Central Highlands. Thus at Mt. Korong near Wedderburne, a porphyritic two-mica granite closely resembling that of the Terricks Range is intruded by a finer-grained non-porphyritic two-mica granite, as is also the case at Pyramid Hill (Mahony 1911). The Wycheproof granite, which occurs as an isolated low hill rising abruptly above alluvial plains, is a course-grained muscovite granite, and the Wooronook intrusion is a coarse-grained two-mica granite. The Buckrabanyule Hills are composed mainly of a complex granodioritic mass showing evidence of considerable contamination, with strong developments of barren quartz veins, tourmaline-quartz veins, and pegmatitic patches. The intrusion near Borung is also granodiorite. It is fine grained, and has a very well-defined grain. Muscovite-bearing granites are rare in Victoria, as elsewhere, and

it is significant that of the few occurrences in the State, five—Lake Boga, the Terricks Range, Wycheproof, Wooronook, and Mt. Korong—should occur in a well-defined arcuate belt on the western and southern borders of the Wimmera. This suggests that the granites of north-western Victoria may belong to a petrographic province distinct from that of the well-known Devono-Carboniferous granitic rocks of the "dacite suite" in the Central and Eastern parts of the State.

References.

Baker, G., 1936.—The Petrology of the You Yangs Granite—A Study of Contamination. *Proc. Roy. Soc. Vic.*, n.s., xlviii. (2), pp. 124-158.

Brammall, A., and H. F. Harwood, 1932.—The Dartmoor Granites: Their Genetic Relationships. *Quart. Journ. Geol. Soc.*, lxxxviii., pp. 171-237.

Derry, D. R., 1931.—The Genetic Relationships of Pegmatites, Aplites, and Tin Veins. *Geol. Mag.*, lxviii., pp. 454-475.

Hills, E. S., 1938.—Andalusite and Sillimanite in Uncontaminated Igneous Rocks. *Geol. Mag.*, lxxv., pp. 296-304.

———, 1939.—The Physiography of North-Western Victoria. *Proc. Roy. Soc. Vic.*, n.s., li. (2), pp. 297-323.

———, 1940.—The Physiography of Victoria. Whitcombe and Tombs, Melbourne.

Mahony, D. J., 1911.—Petrological Appendix to "The Wedderburn Goldfield", by O. A. L. Whitelaw. *Geol. Surv. Vic., Mem.* No. 10.

———, 1936.—Granite near Lake Boga. *Rec. Geol. Surv. Vic.*, v. (2), pp. 259-260.

Mitchell, Major T. L., 1839.—Three Expeditions into the Interior of Eastern Australia. Vol. II., T. & W. Boone, London.

Niggli, P., 1929.—Ore Deposits of Magmatic Origin. Thomas Murby and Co., London.

Schaller, W. T., 1933.—Pegmatities. In "Ore Deposits of the Western United States," pp. 144-151. Amer. Inst. Min. and Met. Eng., New York.

Spencer, E., 1938.—The Potash-Soda Felspars. II.—Some Applications to Petrogenesis. *Min. Mag.*, xxv. (162), pp. 87-118.

Trefethen, J. M., 1937.—The Lincoln Sill. *Journ. Geol.*, xlv., pp. 353-380.

10793/40.—15